MOTION STUDY AS AN INCREASE OF NATIONAL WEALTH

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There is no waste of any kind in the world that equals the waste from needless, ill-directed and ineffective motions, and their resulting unnecessary fatigue. Because this is true, there is no industrial opportunity that offers a richer return than the elimination of needless motions, and the transformation of ill-directed and ineffective motions into efficient activity.

This country has been so rich in human and material resources that it is only recently that the importance of waste elimination has come to be realized. The material element received the first consideration, and in the comparatively few years during which the subject has received attention, an enormous amount has been done to conserve natural resources, to economize in the use of materials, and to utilize the by-products of industiral processes.

The human element is now receiving long-delayed attention. Vocational training, vocational guidance, better placement and better working conditions have become subjects for serious consideration in all parts of this country and of the world. Savings in human energy are resulting from these investigations. But the greatest saving in time, in money and in energy will result when the motions of every individual, no matter what his work may be, have been studied and standardized.

Such studies have already been made in many trades, and have resulted in actual savings that prove that the results of the practice confirm the theory. In laying brick, the motions used in laying a single brick were reduced from eighteen to five, with an increase in output of from one hundred and twenty bricks an hour to three hundred and fifty an hour. In folding cotton cloth, twenty to thirty motions were reduced to ten or twelve, with the result that instead of one hundred and fifty dozen pieces of cloth, four hundred dozen were folded, with no added fatigue. The motions of a girl putting paper on boxes of shoe polish were studied. Her methods were changed only slightly, and where she had been doing twenty-four boxes in forty seconds, she did twenty-four in twenty seconds,

with less effort. Similar studies have cut down the motions not only of men and women in other trades but also of surgeons, of nurses, of office workers; in fact, of workers in every type of work studied.

Motion study consists of dividing work into the most fundamental elements possible; studying these elements separately and in relation to one another; and from these studied elements, when timed, building methods of least waste.

To cite a specific example: The assembly of a machine is the piece of work under consideration. The existing method of assembling the machine is recorded in the minutest detail. Each element of the assembly is then tested—the method used in handling the element being compared with other possible methods. In this way, the most efficient elements of an assembly are determined; and these elements are combined into a method of assembly that, because it is the result of actual measurement, is worthy to become a standard. Such an assembly is that of the braider, manufactured by the New England Butt Company. As a result of motion studies made upon this, where eighteen braiders had been assembled by one man in a day, it now becomes possible to assemble sixty-six braiders per man per day, with no increase in fatigue.

The accurate measurement involved in getting results like this includes three elements. We must determine: first, the units to be measured; second, the methods to be used; and, third, the devices to be used.

The unit of measurement must be one that of itself will reduce cost, and should be as small as the time and money that can be devoted to the investigation warrants. The smaller the unit, the more intensive the study required. The methods and devices to be used are also determined largely by the question of cost. Naturally, those methods and devices are preferable which provide least possibility of errors of observation. Such errors have been classified as of two kinds: first, errors due to instruments; and, second, errors due to the personal bias of the observer. The newer methods of making motion studies and time studies by the use of the micromotion method and the chronocyclegraph method exclude such errors. Fortunately, through an improvement and cheapening of the devices, it is now possible to make accurate records of motions, even when no great outlay for the study can be afforded.

The micro-motion method of making motion studies consists of recording motions by means of a motion picture camera, a clock that will record different times of day in each picture of a motion picture film, a cross-sectioned background, and other devices for assisting in measuring the relative efficiency and wastefulness of motions. Suppose the process of assembly before cited is being micro-motion studied: The assembler is placed before the cross-sectioned background; the micro-motion clock is placed where it will record in the picture, yet not disturb the worker; near it is another clock which serves as a check on the accuracy of the special clock. The assembler, who has been rated a skilled worker under the old method, naturally does the best work possible, since a record is being made of his performance. The observer operates the motion picture camera, which, however, allows him freedom to observe the assembly process continually, and to note possibilities for improvement. From the data on the film and the observations of the observer, an improved method can be formulated. The standard method is seldom derived from the work of one observed worker only. It has been noted that *the ideal method seldom lies in the consecutive acts of any one individual;* therefore, many workers are observed before the final standard is deduced.

These micro-motion records give all the data required except the continuous path of a cycle of motions. This lack is supplied by the chronocyclegraph method. The chronocyclegraph method of making motion study consists of fastening tiny electric-light bulbs to the fingers of the operator, or to any part of the operator or of the material whose motion path it is desired to study. If it is merely the orbit of the motion that is to be observed, a photograph is made of the moving part to which the light is attached, during the time that this part is performing the operation. If the direction, relative time, and relative speed are to be noted, the path of light, through controlled interruption of the circuit, is made to consist of dots or dashes, or a combination of the two, with pointed ends, the point showing the direction.

Through the micro-motion studies and the chronocyclegraph studies, then, the expert formulates the standard method. It is important to note the changes which the installation of a standard method implies. This method consists of improved motions, and

implies, first, changes in surroundings, equipment, and tools; and, second, changes in the type of worker assigned to do the work.

During the motion study of the assembly, it was found that more efficient motions could be made if the machine assembled was placed on a special table, which could be turned on its side and transformed into a lower table, after the base group of the machine had been assmbled. It was also found that speed was gained and fatigue eliminated, when the parts of the machine were arranged in an obvious sequence on a vertical packet. These devices were immediately supplied at little cost and with great result in saving. Through these devices, and the other changes made by motion study, it became possible to accomplish over three and one-half times as much assembly as had previously been done. Such changes are typical, and it is typical that the inventions *result from* the motion study.

As for the type of individual suited to the work, the simplification of the process and the reduction of the motions to habits often make it possible to utilize workers with less initiative and skill, assigning the more skilled workers to a higher type of work. In the case of the assembly, the original assemblers were retained and enabled to do much more work with less fatigue. It has also been possible to train inexperienced men to assemble in much less time and with less effort than was formerly the case.

The result of the introduction of motion standards is an increase in output and wages, and an accompanying decrease in cost. The decreased cost and the increased wages both depend, of course, on the increased output. The output is increased, because the motions used to make any one unit of the output are less in number and more efficient in results. The average cost of output increase is sufficient not only to provide for the higher wages necessary to induce the workers to do the amount of work prescribed, and to enjoy doing it, but also to allow of at least enough profit to the management to cover the cost of the investigations that resulted in the standard.

The *quality* of the output is maintained through a new type of inspection, which considers not only the output itself, but the elements—material and human—which result in that output. Nothing is a higher guarantee of quality than insistence on a standard method.

Along with the laboratory investigations from which motion-study standards are derived, goes a general campaign to arouse every individual in the organization to think in terms of elementary motions. Such simple office equipment as pencil holders are motion studied, and every member of the organization is encouraged to observe and record his own motions in performing the most elementary of operations. Motion study may be carried on with no devices, and everyone is expected to know how to make at least the preliminary investigations. In this way, the spirit of motion economy grows throughout the entire plant, with a consequent elimination of waste motions and a growing interest in the more scientific methods of motion study.

What, now, are the results of this motion study upon the individual men doing the work, upon the factory group, upon the industrial world and upon society at large? The men themselves become more efficient. They become specialists—skilled workers. They learn the motion-study method of attack, and are thus more fit to undertake any type of work. They learn to think in elementary motions, and to eliminate waste in every activity of their lives. The increased output of each individual worker does not result in the employment of less men in the plant. The transference of skill that maintenance of standards implies, means that many teachers are needed. These come, naturally, from the ranks of the skilled workers. The planning that is necessary is also usually done by workers promoted to the planning department. At present, at least, the demand for men trained under motion study is far larger than the supply; it will be for years to come—certainly until the increased output results in the increased demand which is its inevitable consequence.

The industrial situation is bettered through the general spread of the ideas of waste elimination, and through the practical application of its principles in whatever relations those trained under it may enter. How far this influence upon the industries will extend will depend entirely upon the amount of work done by individuals, and upon their coöperation. At present, many individuals are engaged in, or are at least interested in, motion study and waste elimination. But there is not the proper degree of coöperation. Such coöperation can only come as motion study becomes a matter of interest to society at large. The whole social group is already being affected

by the results of motion study. One typical result is the gradual filling in of the gap between the school and the plant. An intensive study of motions is proving that there are far greater likenesses in trades, and even professions, on the mechanical side, than we have ever believed possible. The demand of the industrial world will be more and more for young workers trained to be finger-wise, with a knowledge of the fundamentals of motion economy, and with an understanding of the relationship between efficient motions and success in the industries.

The industrial world is becoming more and more definite in its requirements for industrial training. This is making it possible for all types of schools to give their pupils a training which enables them to fit into working conditions without the customary, preliminary jolt, and months and years of adjustment. The training required is so general, yet so definite, that it may well prove an important part of the training of every young man or woman, whether he goes ultimately into the industries or not. This training is being given not only in the technical schools and in the trade schools but also to some extent, at least, in the ordinary public schools. It consists of making every pupil, to as great an extent as possible, "finger-wise," that is, of training his muscles so that they respond easily and quickly to demands for skilled work. With this training goes an appreciation of the importance of such "finger training," and of its relation to motion economy. The pupils are also given an appreciation of the problems of industry, and of the relation of these problems to social development.

An effect of motion study in the industries upon society is its influence toward spreading the belief that real efficiency considers and conserves the human element; that it makes fatigue study imperative; and that its fundamental idea is conservation, not exploitation.

The great need today, as in all fields where progress is to be made, is education. The community as a whole must be educated as to the importance of motion study, and as to the possibility of every man and woman making such motion study to some extent for himself. The technical press and the press generally are doing much to spread these ideas. Much is also being done by the colleges, where many are studying and teaching the subject. Such widespread education is absolutely necessary before we can hope for

the reclassification and standardization of the existing trades, which is a necessary future step. The trades must be reclassified, according to the amount of skill involved in the motions used; and must then be standardized in order that the necessary training for entering them and succeeding in them can be given. As an example of reclassifying a trade, we would recommend, for example, for brick work, five classes:

Class A—Ornamental and exterior face brick and molded terra cotta.

Class B—Interior face tiers that do not show at completion, where strong, plumb and straight work only is needed.

Class C—Filling tiers where only strength is needed.

Class D—Putting fountain trowels and brick packs on the wall near the place, and in the manner where the other three classes can reach them with greatest economy of motion.

Class E—Pack loaders, brick cullers and stage builders.

The pay of the A and B classes should be considerably higher than is customary for bricklayers. The pay of the C, D, and E classes should be lower than is customary for bricklayers, but much higher than the pay of laborers. This classification will raise the pay of all five classes higher than they could ever obtain in the classes that they would ordinarily work in under the present system, yet the resulting cost of the labor on brickwork would be much less, and each class would be raised in its standing and educated for better work and higher wages. In the case of brickwork this new classification is a crying necessity, as the cost of brickwork must be reduced to a point where it can compete with concrete. Improvements in making, methods of mixing, transporting, and densifying concrete in the metal molds of today have put the entire brickwork proposition where it can be used for looks only, because for strength, imperviousness, quickness of construction, lack of union labor troubles and low cost, brickwork cannot compete with concrete under present conditions. Having sub-classified the trades, the second step is to standardize them. And both classification and standardization demand motion study.

The other great need, besides education, is, then, a bureau of standards, where work done in motion study can be collected, classified, and put into such form that it will be available to everyone. There is an enormous waste, at present, from repeating investigations

along the same lines of work. There is not only the waste from the actual repetition involved, but also the fact that the time utilized in doing work already done could, instead, be devoted to the original work that is sadly needed. It is the work of the United States government to establish such a bureau of standardization of mechanical trades. The standards there derived and collected would be public property, and original investigators could invent from these standards upwards. Most important of all, perhaps, these standards would furnish the ideal means for teaching or transferring skill to the young workers who desire to enter a trade.

The reclassification of the trades and the bureau of standardization are, then, the two great needs for motion study development. But these will come only when the individuals interested apply motion study to their own work, and show willingness to coöperate with others.

The industrial opportunity afforded by motion study is not, then, some great future opportunity of which we dream, or some remote and inaccessible opportunity for which we must collectively strive. It is an opportunity ready, here and now, to be grasped by each one of us individually—and it is the greatest industrial opportunity that this century affords.